SCIENCE-TEACHING IN THE SCHOOLS.

BY WM. NORTH RICE.

[Continued from page 774.]

BUT many who concede theoretically the desirableness of the study of natural science in the lower schools, maintain that the practical difficulties in the way of its introduction are insuperable. It is objected that we have no competent teachers, no adequate material facilities, and no time in the already crowded curriculum. Science-teaching in the lower schools, it is said, belongs to that far-off millennium

"When the war-drum throbs no longer, and the battle-flags are furled,—

when a constitutional amendment has abolished alcoholic fermentation, and made vice forever impossible,—when governments, no longer compelled to support military, naval, and police forces, can spend the bulk of their revenues on education,—when every primary school can have a well-equipped laboratory, museum, and observatory,—when every primary school teacher is a Ph.D. of a German university,—and when a reformed orthography has added about three years to school life, by obviating the necessity of spending that time in learning to spell. I believe, however, that the reform is thoroughly practicable. My own official duty, as a member of a college faculty and of a city school board, has required a careful study of all parts of the educational curriculum in a thoroughly practical spirit. And I should regard the general discussion I have given as of little value, unless I could propose some definite and practicable measures.

The most serious difficulty in the introduction of natural science into the lower schools is undoubtedly the lack of competent teachers. That the mass of our teachers are incompetent for any very high quality of science-teaching, is a truth as unquestionable as it is melancholy. That much of their teaching will be merely bookish,—that much of it will be so blundering that the scholars will have a good deal to unlearn,—is very certain. This difficulty has

been so strongly felt by many scientific men, that they have despaired of any successful science-teaching in the schools till a new generation of teachers can be raised up. "Better no teaching at all than poor teaching," is the principle on which they feel themselves reluctantly compelled to advocate the postponement of a reform whose need none can feel more strongly than they. But I believe the worst teaching we are likely to get is better than none. Very poor teaching of science will at least serve to keep before the mind of the child the idea that there is an external world which is worthy of attention and study. Better that many errors should be learned, than that the child should grow up without thinking of nature at all. No habitude of mind that is likely to be generated by poor teaching can be so bad as the habitude of stolid indifference which is the natural result of the present system. If we wait for teachers well prepared, before we introduce science-teaching, we shall wait indefinitely. Teachers will prepare themselves after a fashion to teach whatever they are required to teach. No way of making a boy swim has ever been found so effective as putting him into the water.

There are books in abundance (and the number is constantly increasing), from which a teacher possessed of a fair degree of mental activity can get suggestions which will enable her to do a limited amount of science-teaching soundly and well. Paul Bert's "First Steps in Scientific Knowledge" is an admirable guide for teachers of elementary science. Morse's "First Book of Zoology," and Winchell's "Geological Excursions," are books in which acknowledged masters of science have shown how science may be taught to the young. The series of scientific tracts for teachers now being published under the auspices of the Boston Society of Natural History are good, as judged from both the scientific and the pedagogic standpoint. Worthington Hooker's books of science for children, though now somewhat behind the times, are still attractive and helpful books. And the teacher who cannot find something to interest the youngest in Johonnot's series of natural history readers, with their delightful blending of fact and fancy, the science and the poetry of animated nature, is stupid indeed.

The teaching of science in the lower schools can be considerably helped by the teachers in the high schools. In most high schools it is practicable to obtain the services of one or more teachers who

have had some genuine scientific training. Arrangements can be made whereby these teachers can now and then give a helpful lecture to the teachers of the lower schools, or give to those teachers the best kind of an object lesson by teaching a lesson in science to the children in their schools.

The summer schools and seaside laboratories afford the means for teachers whose early opportunities for scientific study were scanty, to gain a sound (though necessarily limited) knowledge of scientific facts and methods. The increasing number and the increasing patronage of such institutions is a hopeful sign. They are destined to be of immense service in improving the quality of science-teaching.

The second objection usually urged against the introduction of science-teaching in the lower schools is the lack of material facilities. The force of this objection, however, vanishes, when it is considered that no one proposes for the lower schools complete systematic courses in science. Such courses would indeed demand extensive laboratories and museums. But for somewhat desultory lessons on judiciously selected topics in science, whose aim is primarily to cultivate the powers of observation, and secondarily to afford glimpses of the methods of scientific thought, no extensive material facilities are needed. Many of the most important principles of physics and chemistry can be well illustrated with no apparatus except what can be extemporized. A class of tolerably active boys can collect enough material for biological study as they go along. Many of the most important conceptions of philosophical biology can be illustrated without any specimens which are not everywhere accessible. A boy who has found the elbow, wrist, knee, and ankle, in a cat, a horse, a bat, and a hen, has learned the idea of homology, though he has never compared the arms of a brachiopod with the lophophore of a bryozoan, and never heard of the gastræa theory.

The third objection usually made to scientific study in the schools —the lack of time in the crowded curriculum—hardly deserves an answer. Let the waste of time and mental energy be stopped, which is involved in attempting studies at unnatural times and in unnatural ways, and there will be time enough. Of all economies, the most important is the most neglected—the economy of mental effort. I believe the introduction of science-teaching in the schools will be felt by the pupils as a delightful recreation, rather than as

an additional task; and that the improvement of morale will actually enable the schools to accomplish more in other studies.

It remains, then, to outline briefly the work which may be profitably attempted. In the primary schools, and the lower grades of the intermediate, or grammar, schools, the main objects must be to keep alive the child's curiosity in regard to natural objects, to cultivate the power of accurate observation, and to impress the mind with the idea that nature is worth studying. The attempt to teach any systematic body of facts and doctrines, so far as it is made at all, must be strictly subordinated to these more general objects. Hence it is no matter how desultory the lessons may be, if they tend to keep the mind of the child in loving communion with nature. The pupils should be encouraged to collect and bring to school specimens of all sorts of natural objects. So far as time allows, each specimen should be the subject of a lesson. Judicious questioning should bring out all the facts and phenomena which the child has observed or can observe in regard to the specimen. Then the teacher should add something of explanation or information in regard to the object itself or other related objects. And let questions be suggested now and then, which the child and his elders are alike unable to answer. Thus the child will become early habituated to the complementary truths of the transparency and the unfathomableness of nature. He will learn that he can see into nature a little way for himself, but that beyond his vision stretches a vast unknown. The specimens brought in will be an utterly heterogeneous collection—now a bright-winged butterfly, now a flower, now a plant with insect galls, now a sea-shell brought home from some summer visit to the sea-side, now a lustrous crystal, now a smoothly rounded pebble. All the better. Let the children learn the manifoldness of nature. It will be time enough later for them to survey the fences of systematic definition which man has run through nature's continuous and illimitable fields. Short excursions in the woods and fields (or in the parks which afford almost the only glimpses of nature to the unfortunate children who are brought up in the great cities), and visits to museums, zoological gardens, and menageries, will be helpful supplements to the work of the school-room.

Besides the utterly desultory lessons already considered, a beginning may be made in the primary schools in somewhat more sys-

tematic teaching. The objects most interesting to children are living things—plants and animals. Botany and zoology should accordingly be the principal subjects in the science-teaching in the lower grades. The comparison, drawing, and description of various forms of leaves, will furnish delightful occupation and valuable discipline for the youngest children. A little later the more easy and conspicuous flowers can be studied, and later still the more obscure and difficult flowers. In zoology, attention should be given not to crinoids and hydroids and infusoria, but to the mammals and birds and reptiles and fishes and insects which the children can see alive. In places immediately on the sea-shore, some of the more conspicuous marine animals may advantageously be included. The most common and familiar mammals, as cats, dogs, horses, rats, should be first studied; and rudimentary ideas of homology and teleology and the principles of classification can be developed in the study of these most familiar objects. From mammals the study may proceed in later years to birds, and then to the less familiar lower classes of vertebrates, and later still to arthropods and molluscs. Along with the change of subjects, there will naturally be somewhat of a change of method. There will be less of simple observation and description of external characters, more explanation of anatomy and physiology, and more discussion of general relations.

In several of the States, laws have been passed, requiring in all the schools instruction in physiology and hygiene, with special reference to the effects of stimulants and narcotics. There has been an element of fanatical exaggeration in the philanthropic agitation which has led to such legislation, and some of the books which have been prepared, and some of the teaching which has been done, in obedience to the demand, have not been of great scientific value. I believe, nevertheless, that simple lessons in physiology and hygiene may with great advantage be commenced in the primary schools. It is indeed true that physiology can be taught only in a very unsatisfactory manner to pupils ignorant of chemistry and physics, for physiology is essentially chemistry and physics applied to the complex structures and actions of the living body. But very imperfect knowledge is better than absolute ignorance. And the immense importance of the subject, in connection with the fact that only a very small minority of the pupils will ever reach the

high school, more than justifies the attempt to teach some rudiments of physiology in the lower schools.

Somewhat of physical geography will naturally be taught in the higher grades of the primary, and the lower grades of the grammar, schools, in connection with the general course in geography. It is very gratifying to observe the change in the school manuals of geography within the last few years, in respect of the greater prominence given to physical geography.

In the higher grades of the grammar schools, it may reasonably be assumed that the reasoning faculties are more fully developed than in the lower grades, and observation and description of forms may rightly give place in large degree to studies in which the relation of cause and effect is emphasized. This will be the most convenient period for the introduction of exceedingly elementary courses in physics and chemistry. The pupils who will never enter the high school ought to get some rudimentary knowledge of these sciences; and a like rudimentary knowledge obtained in the grammar school will be of great advantage to the students in the high-school course. Of course, at this stage it will not be desirable or possible to penetrate into the mysteries of polarized light, to enumerate the scores of rare elements, or to discuss the more intricate problems of the chemistry of the compounds of carbon. But it will be possible, in the later years of the course in the grammar school, to learn some of the more important facts and principles in regard to gravitation, the mechanical powers, the simpler and more obvious phenomena of sound, light, heat, and electricity, the distinction between elements and compounds, combustion, the chemistry of air and water, and the properties of a very few of the most important elements and their compounds.

When the student reaches the high school, he will be possessed of some knowledge of the forms of common animals and plants, the structure and functions of his own body, and the general properties of matter. What is more important than any knowledge of nature which he may possess—he will have kept himself in sympathetic communion with nature; he will recognize nature as a worthy object of study; he will know that he can learn something himself by the observation of nature, but that he has learned only an infinitesimal part of what nature has to teach. His conceptions will be crude, indefinite, inaccurate. His knowledge will require

elaboration, systematization, correction. But he will not find the book of nature written in a language whose alphabet he does not know. As he comes to the systematic study of the various sciences he will not feel that utterly bewildering sense of strangeness with which teachers in our high schools and colleges are now so sadly familiar. In the high school, he will come under the instruction of teachers possessed of larger knowledge, and supplied with more extensive material facilities. Now then the time has come for *systematic* teaching of science. Random observation and desultory stories of nature must now give place in large degree to the presentation of systematized bodies of fact and theory.

With the beginning of the high-school course comes the separation between those who are preparing for the classical courses in the colleges, and those who are destined to go from the high school directly into practical business life. For the former class the systematic study of science may be mainly deferred until they can enjoy the larger material facilities afforded by the laboratories, museums, and observatories of the colleges. I believe, however, that the complete exclusion of scientific studies from the classical courses in many of our high schools is greatly to be regretted. There are three scientific studies which I would have placed early in the high-school course, and required of both the English and the classical students.

First in this list I would name phænogamic botany. There is no study which can conveniently be made to furnish so admirable a discipline in observation. The material is everywhere accessible in abundance. The collection and dissection of the specimens involves no infliction of pain upon sentient creatures. The débris remaining after a lesson is comparatively clean, inodorous, and wholesome. In all these respects phænogamic botany is better adapted for thorough practical study at this stage than any branch of zoology. The structures which are to be examined in the analysis of flowering plants are also of about the right size to afford the most valuable discipline in accurate observation. The work is neither too easy, nor too difficult. It requires the use of the inexpensive simple microscope, but not the use of the costly compound microscope. A thorough training in plant analysis at this period of the educational course will afford a mental discipline which can be supplied in no other way.

Secondly, I would require of all students at this stage the study of human physiology. The immense practical importance of this branch of knowledge is a sufficient reason for this recommendation. The outlines of physics and chemistry which I suppose to have been taken in the later years of the grammar-school course, will enable the teaching to be more thoroughly scientific in method than can be the case in the lower schools. And, while the study cannot be made so much of an observational discipline as botany, there is no lack of material for demonstration. Most of the organs of the body present the same general character in other mammals as in man. Hearts, lungs, brains, and eyes can readily be obtained from the butchers, and a superfluous cat can be occasionally sacrificed. And, with the various convenient guides to mammalian dissection which have been published, there is no reason why a high-school course in physiology may not be illustrated with a fair amount of demonstration.

Thirdly, a systematic study of physical geography will be invaluable in giving the student an appreciation of the world as a whole—its unity in variety—unity of law amidst endless diversity of phenomena. No study so opens to the student's intelligence the language of nature, teaching him to read the lessons written in the ever varying landscapes which he may from time to time behold.

It is, in my judgment, greatly to be desired that these studies should be included in the requirements for admission to the colleges. As students naturally desire to enter college as early as possible, there is a strong tendency for the preparatory schools to exclude from their classical courses everything not required for admission to college. The requirement of a small amount of natural science by the colleges would greatly favor the progress of the reform in the schools.

For the students in the high school who are not in the classical course, there should be in addition systematic studies of physics, chemistry, zoology, geology, and astronomy. For them, natural science should certainly be a required study during the whole of the high-school course.

While the study of natural science has been advocated on the twofold ground of its practical and its disciplinary value, it has been assumed in this discussion that these two objects are by no means of equal relative importance in the study of different branches

of science or in different periods of the educational course. The study of botany has been advocated especially for its disciplinary value, that of physiology especially for the utility of the knowledge which is acquired. It has been maintained that in the primary school the main objects of the science lessons must be to cultivate a habit of accurate observation and intelligent appreciation of nature, while in the high school each science should be taught as a systematic body of fact and theory. This leads us to notice the unfortunate truth that the two objects of scientific study are to a certain degree incompatible with each other—that the best methods for mental discipline are not the best methods for the acquisition of information. Undoubtedly the method by which the characteristic mental discipline of scientific study can be most effectively secured, is to put the student as nearly as possible in the attitude of the original investigator—to lead him to infer laws and principles from the observations and experiments which he has made himself. But the path taken by the original explorer of a country is often not the most convenient route for subsequent travelers. And a knowledge of laws and principles in science once ascertained can often be taught in ways far more expeditious and convenient than the method of their original discovery. Moreover, many of the most important conclusions rest upon observations only possible in exceptional conditions of time, place, and circumstance. Every student should learn the laws of definite and multiple proportions, which form the foundation of chemical theory; but the ordinary student has no time to perform such a number of experiments in quantitative analysis and synthesis as would make a sound inductive basis for those laws. Every student should learn something of the phenomena and laws of earthquakes and volcanoes; but it is impossible to get up an earthquake or a volcanic eruption for a laboratory experiment. It is well for every student to learn something of the conclusions in regard to the action of the stomach reached by the classical observations on poor Alexis St. Martin; but it is hardly desirable to repeat St. Martin's accident and injury for the benefit of every class in physiology. The right method of scientific education must be a compromise. The most important facts and principles must be taught by text-books and lectures, in such way as to secure most effectively their being understood and remembered. But, so far as the nature of the sub-

ject and the time and means at the disposal of the teacher may allow, mental discipline must be secured by having the student tread for himself the path of observation and experiment, comparison and inference.

This difficulty in science-teaching is somewhat relieved by the consideration that a single fact learned by actual observation or experiment, serves to render real the knowledge of allied facts made known by the second-hand process of description, which would otherwise be shadowy and unsubstantial. The student who has made a few quantitative determinations in chemical analysis, understands the meaning of the analyses which he finds in books. The student who has handled the bones of one animal, can read intelligently the description of other skeletons.

In conclusion, I would most emphatically repeat that a plea for the study of natural science is not a plea against other studies. All the studies which have a place in the educational course, have their place by reason of their capacity to afford sound mental discipline and useful knowledge. All true education is broadening and liberalizing in its tendency. Whatever the special studies which natural tastes or professional plans may lead the student to pursue in the later years of his educational course, or whatever the pursuits in which he may engage after leaving school, he will have learned, if rightly taught, an appreciative respect for all the great branches of study in which the human intellect has engaged. He will not despise the study of languages, bringing him into communion with the great minds of other ages and other nations; nor the study of language, interpreting the structure and development of earth's myriad tongues. He will feel the dignity of that pure truth which is embodied in mathematics, and will appreciate the immense utility of the applications of mathematics in the arts of a material civilization. He will have learned in due time that he has a soul as well as a body; and will appreciate the study of the human mind, as revealed to the direct gaze of consciousness, or as expressing itself in literature and history. And the double world of sensation and consciousness will disclose to him its highest meaning, in the revelation of Him

> "Whose dwelling is the light of setting suns,
> And the round ocean, and the living air,
> And the blue sky, and in the mind of man."

But, whatever sources of light may shed their beams upon his advancing intellect, the first star which rose above his horizon will never set. Whatever teachers he may listen to, the one whose gentle voice first roused him from the slumber of unconsciousness will never be forgotten. As his first lessons were from nature's teaching, she will have for his expanding mind lessons continually new. He will

> "Find tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

Note.—It is proper to say that the address was not written previously to its delivery before the Society of Naturalists; and that, in writing it in its present form, I have incorporated some ideas which were suggested in the discussion at the meeting, and some which have been the fruit of further reflection. The article is, however, in the main a reproduction of the address as given.

In July, 1888, the Board of Education of the City of Middletown, Conn., adopted a new Manual for the Schools of that city. The new course of study provides for instruction in Natural Science in all grades from the lowest Primary upward, on a plan substantially the same as that which I have recommended. As a sort of practical comment on the views of the address, I append an extract from the Middletown School Manual, giving the instructions to the teachers in the Primary and Grammar grades in regard to instruction in Natural Science. The portion of the Manual here quoted was written by myself in connection with the Superintendent of Schools, W. B. Ferguson, M.A.

Extract from the Manual of the Public Schools of Middletown, Conn.

NATURAL SCIENCE.

Introduction.—The object of elementary lessons in Natural Science is twofold:—to train the observing powers, and to give information. The former should be especially emphasized in the Primary Grades, and the two made about equally important in the Grammar Grades.

The teaching should be chiefly objective. Large, well-defined pictures may be used, whenever it is impossible to obtain the real objects; but it should always be borne in mind that the best pictures are poor substitutes for the objects themselves.

In the lowest grades, the teacher should studiously avoid the use of technical terms, whose meaning is unknown to children. The chief object here is, not to teach science, but to train to close and accurate observation, and to stimulate a keen interest in nature. In no grade should special emphasis be laid upon technical terms and classifications, though somewhat more attention may properly be given to them in the Grammar grades. All classifications should, so far as possible, be the result of observation and comparison on the part of the pupils. Let the teacher stimulate, direct, and name. Happy the teacher and fortunate the pupils, if, in this delightful work, the teacher judiciously combines speech and silence. An occasional talk, however, by the teacher on the subject before the class is both proper and desirable. Such talks should furnish information beyond the reach of the pupils' observation.

Every lesson should be carefully prepared. Aimless and irrelevant conversations are profitless. Allow and encourage the freest expression of what the pupils see. *Encourage the pupils to collect and bring in specimens. Elicit, by judicious questions, a description of what they have brought. Give them additional information. If necessary, postpone the subject till the next day, and learn something about it.*

GRADE I.

Physiology.—Regions of the body—head, trunk, limbs. Details of external parts. Uses of external organs. Hygiene of the skin—bathing.

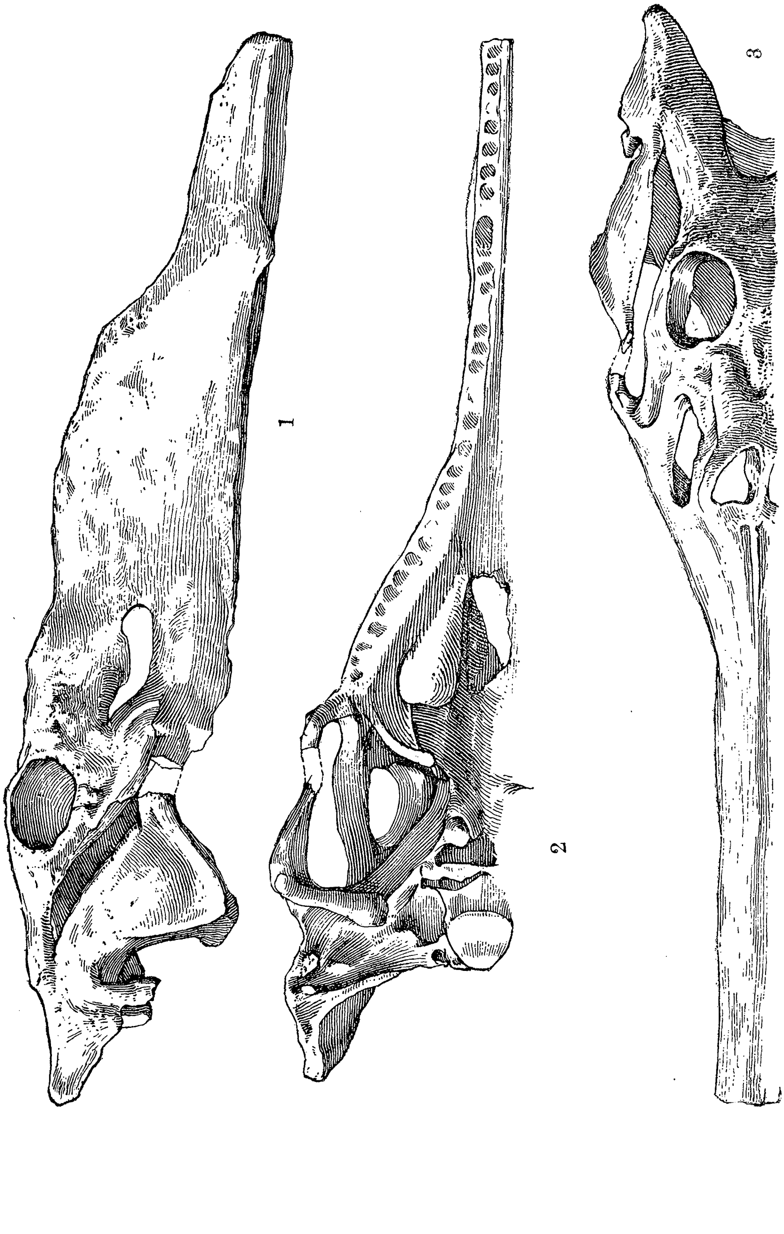
Zoology.—Lessons on common mammals—*e.g.*, cat, dog, horse, cow, rat, squirrel. Let the pupils observe, compare, and describe these animals, as regards their external aspect and habits. Compare these animals with ourselves. Tell stories illustrative of habits of these and other mammals.

Botany.—Lessons on common plants. Teach pupils to distinguish root, stem, leaf. Compare leaves of different plants, as regards general form, margin, venation. Require pupils to draw and describe leaves of many plants.

GRADE II.

Physiology.—The framework of the body. Bones, joints, muscles. Exhibit anatomical diagrams. Teach the pupils to find in their own bodies some of the bones which can be easily felt through

PLATE XVII.



Cranium of *Belodon buceros* Cope, from Southwestern New Mexico.

the skin. Emphasize importance of correct attitudes while the framework of the body is rapidly growing and taking shape. Warn against stooping shoulders and crooked backs. The teeth—their forms and uses. Emphasize importance of proper mastication. Necessity of cleaning teeth.

Zoology.—Lessons on mammals continued. Special study and comparison of limbs of mammals. Let the pupils find the elbow, wrist, knee, and ankle, in the cat, dog, horse, cow, rat, squirrel, and any other mammals of which specimens or pictures may be at hand. Thus teach the idea of homology, though the word should not be used. Compare the teeth of common mammals, and lead pupils to recognize adaptation of different kinds of teeth to different kinds of food. Teach pupils to recognize degrees of resemblance between animals. The cat and the dog resemble each other more than either resembles the horse or the rat. Develop idea of classification. Lead pupils to recognize characters of carnivores, ungulates, rodents. Most of the mammals with which the children are familiar are included in these three orders. But tell them about monkeys and kangaroos and other very different forms of mammals, that they may not suppose that all mammals are so included.

Botany.—Different kinds of stems—woody and herbaceous, exogenous and endogenous. By study of numerous examples lead pupils to recognize that exogenous stems usually bear net-veined leaves, and endogenous stems usually bear parallel-veined leaves. Distinguish deciduous and evergreen trees. Let the pupils make lists of each.

GRADE III.

Physiology.—Elementary ideas of digestion. Why do we eat? All parts of the body are made of the food which we eat. Food is made into blood, and blood made into all the materials of the body. But our food is mostly solid, and must be made liquid before it can get into the blood. Different substances dissolve in different liquids—*e.g.*, salt in water, camphor gum in alcohol, iron filings in dilute sulphuric acid. Show these experiments. Body itself must make liquids which will dissolve food. Put lump of sugar in mouth. Mouth fills with saliva, and sugar is dissolved. This illustrates secretion of digestive fluids. But meat will not dissolve in saliva. What does become of it? Show

anatomical plate of stomach, and tell about gastric juice. Teach (with use of anatomical diagrams) outlines of anatomy of digestive organs. Show by experiment how much more quickly powdered salt dissolves in water than lumps of rock salt. Teach importance of thorough mastication. Show gizzard of turkey, and explain its use. But we have no gizzard; and hence must not swallow our food whole, as the turkey does. Wholesome and unwholesome foods. Alcohol.

Zoology.—Lessons on common birds—*e.g.*, robin, hawk, hen, duck. Let pupils compare these with each other and with mammals. Compare feet and bills of different birds, and show adaptation to habits. Continue lessons on homology of limbs. Let the pupils find elbow, wrist, knee, and ankle, in birds. Is the bat a bird? Talks on instincts of birds shown in periodical migrations and nest-building.

Botany.—Lessons on flowers. Select plants with perfect and somewhat conspicuous flowers. Teach pupils to recognize sepals, petals, stamens, pistils. Let pupils describe and draw the parts in a variety of flowers. Study polypetalous flowers first, afterwards monopetalous flowers. Cut open the ovary in large flowers, and show the ovules. Develop the idea that the parts of a flower are altered leaves.

GRADE IV.

Physiology.—Circulation. When food has been made into blood, blood has to be carried to all parts of the body—function of circulation. Show by anatomical plates the outline of anatomy of circulatory apparatus. Let pupils find some of their own veins, and feel pulsation of heart and of arteries in wrist and temple. Respiration. Show difference between inspired and expired air by experiment with lime-water. Burn a candle in a jar, and show that the air in the jar affects lime-water like expired air. Carbonic acid always formed when carbon burns—*i.e.*, when carbon unites with oxygen. Carbon in body and in food. Carbon burns—*i.e.*, unites with oxygen,—all over the body. Body runs, like a steam-engine, by burning carbon. Object of respiration—introduction of oxygen, and removal of carbonic acid. Anatomy of respiratory organs. Hygiene of respiration—dress, ventilation. Respiration in aquatic animals. Show gills of fish, and respiratory movements in living

fish. Fish breathes air dissolved in water. Show presence of such air by warming a beaker of water, and so forming air-bubbles.

Zoology.—Lessons on common reptiles, amphibia, and fishes—*e.g.*, turtle, snake, frog, perch, pickerel, eel. Let pupils observe, compare, and describe. Continue studies of homology of limbs. How many of these animals have two pairs of limbs like those of mammals and birds? Notice external covering of these animals. Their bodies are cold. Why? Respiration of fishes. Is the whale a fish? Metamorphosis of amphibia, as shown in changes from tadpole to frog. Teach characters of the three classes—reptiles, amphibia, fishes. Characters possessed in common by mammals, birds, reptiles, amphibia, fishes. Sub-kingdom vertebrata.

Botany.—The pistil of a flower developes into a fruit. Different kinds of fruits. Seeds. Show the embryo in beans and other large seeds. Plant seeds in pots, and show growth of plants from seeds. Cycle of growth, reproduction, death.

GRADE V.

Physiology.—Nervous system. Analyze the series of actions when a boy puts his hand on the radiator, and finds it too hot. Nervous system a telegraphic system in the body. Brain the central office. Afferent and efferent nerves. Anatomy of the nervous system. Hygiene of the nervous system—stimulants and narcotics.

Zoology.—Study the lobster. Lead pupils to recognize jointed external skeleton, distinct regions of body, jointed limbs. Trace similarity of structure in feelers, jaws and accessory jaws, nippers, legs, and other appendages, including the caudal fin. Cut off edge of carapace on one side, and show gills. Contrast articulate type of structure, as shown in lobster, with vertebrate type, as shown in animals previously studied. Compare diagrams of nervous systems in vertebrates and articulates. Compare with the lobster, the crab and the sow-bug. Teach pupils to recognize the common characters which unite these animals in the class crustacea. Study angle-worm, as illustrating articulate type in much simpler form—body not differentiated into regions, no jointed appendages. Talks on useful animals.

Botany.—Study more obscure and difficult forms of flowers than those examined in Grade III. Flowers densely aggregated, as in sun-flower, dandelion, daisy. Imperfect flowers, as in wil-

low, oak, chestnut. Flowers with open (gymnospermous) pistil, as in pine, spruce.

GRADE VI.

Physiology.—Briefly review work of previous grades. Special study of the eye. Anatomy of the eye. Illustrate formation of image on retina by use of a large lens. Hygiene of the eye. Injury of eye by use of light too strong, too feeble, unsteady, or improperly placed. Cultivation of near-sightedness by bad positions in reading and writing.

Zoology.—Study common insects, as the bee, butterfly, fly, beetle, squash-bug, dragon-fly, grasshopper. Compare these animals with lobster, sow-bug, and angle-worm, and recognize in all these the common character of articulates. In insects, note the characteristic division of body into head, thorax, and abdomen. Compare wings of insects as regards number, form, venation, texture. Show scales from wings of moth and butterfly under microscope. Examine the mouth parts of those insects which are not too small. Supplement observation with pictures. Under lens examine eyes of insects. Explain their peculiar structure. Metamorphosis of insects. Catch some caterpillars in the fall, and keep them in boxes in the school-room. Some of them will probably survive and appear as moths or butterflies early in the spring. Talks on injurious animals. Show how some animals are useful by destroying injurious animals —*e.g.*, insectivorous birds.

Botany.—Distinction between flowering and flowerless plants. Examples of flowerless plants—ferns, club-mosses, horse-tails, mosses, lichens, fungi, sea-weeds. Show fructification of ferns. Show that the distinction of root, stem, and leaf, so obvious in nearly all flowering plants and in ferns and others of the higher flowerless plants, vanishes entirely in fungi and sea-weeds.

Mineralogy.—Study crystalline form, cleavage, color, lustre, hardness, of some of the minerals common in the vicinity of Middletown—*e.g.*, quartz, feldspar, mica, hornblende, garnet, tourmaline, beryl.

GRADE VII.

Physiology.—Senses of hearing, smell, taste.

Zoology.—Study the river mussel. Direct pupils' attention to shell (with its hinge, ligament, mantle-impression, and muscular impressions), mantle, gills, palpi, mouth, foot, adductor muscles.

Compare this animal with the oyster and the clam. Note that the former has only one adductor muscle; while the latter has the mantle lobes united, forming a sack which is continued posteriorly in the breathing-tubes, or siphons. Examine some pond-snails. These will be found to resemble the preceding in their flabby, unjointed bodies, destitute of internal skeleton; but will be seen to differ in having a distinct head with feelers, and a spiral univalve shell. Examine shells of some of the sea-snails. Lead the pupils to recognize characters of Lamellibranchiata and Gastropoda, as classes of the sub-kingdom Mollusca. Contrast the Mollusca with the Vertebrata and Articulata. Give some talks on corals, sponges, and other animals lower in the scale than mollusks. Do not let the pupil suppose that the classes he has studied comprise the whole animal kingdom. Talks on geographical distribution of animals. Give a little idea of geological succession of animals.

Botany.—Geographical distribution of plants. Uses of plants. Relation of plants to animals.

Geology.—Gravel, sand, clay. Show that these result from the disintegration of pre-existent rocks. Erosion, transportation, and deposition by water. Study gutters and puddles for illustration of action of aqueous agencies. Conglomerate, sandstone, shale. Show that these result from consolidation of gravel, sand, clay. Visit Portland quarries. Other rocks are sediments not merely consolidated, but crystallized by action of internal heat. Study specimens of gneiss and mica schist. Contrast their texture with that of sandstone and other sedimentary rocks. Still other rocks have come up in molten condition from interior of globe—*e.g.*, lava, trap. Talks on volcanoes.

GRADE VIII.

Physiology.—Review nutritive functions, using elementary text-book. Illustrate subject with a few dissections.

Physics.—Elementary text-book. Illustrate with experiments, as much as practicable.

GRADE IX.

Physiology.—Review functions of relation, using elementary text-book.

Chemistry.—Elementary text-book. Illustrate with experiments, as much as practicable.